The effect of narrowed gastric conduits on anastomotic leakage following minimally invasive oesophagectomy†

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Abstract

OBJECTIVES: Anastomotic leakage remains a major complication following minimally invasive oesophagectomy (MIO). In this study, our objective was to determine whether a narrower gastric conduit would lead to lower incidence of anastomotic leakage following MIO.

METHODS: In this retrospective study, patients with oesophageal cancer undergoing MIO were assigned to receive 5-cm-wide gastric conduits (from May 2011 to February 2012, Group W) and then 3-cm-wide gastric conduits (from March 2012 to December 2012, Group N) for gastro-oesophageal anastomosis. The length of the gastric conduit and the anastomotic details were recorded during surgery. Perfusion status of the conduit was analysed before and after anastomosis using a laser Doppler perfusion monitor. Following surgery, the incidence of anastomotic leakage in the two groups was statistically compared to identify differences between the two methods of gastric formation.

RESULTS: There were 126 patients in Group N and 133 patients in Group W. Patient demographics and surgical observations were comparable between the two groups. In Group N, the length of gastric conduit was significantly greater than in Group W (39.1 ± 2.7 vs 35.6 ± 4.4 cm, P = 0.0021). Lower reduction of perfusion units was recorded in Group N after gastro-oesophageal anastomosis (45.7 vs 28.1%, P = 0.004). Postoperatively, a total of 34 cases (13.13%) of anastomotic leakage was observed, and the incidence of anastomotic leakage was significantly lower in Group N than in Group W (8.7 vs 17.3%, P = 0.041).

CONCLUSIONS: Narrow gastric tubes were longer and less interfered in perfusion, which contributed to lower incidence of anastomotic leakage following minimally invasive oesophagectomy. Further study of the long-term effects of such treatment is required to confirm the advantages of this technique.

Keywords: Anastomotic leakage • Minimally invasive oesophagectomy • Gastric conduit

INTRODUCTION

Recently, a lower incidence of pulmonary complications following minimally invasive oesophagectomy (MIO) has been reported in several publications [1, 2]. However, complications due to gastro-oesophageal reconstruction, especially anastomotic leakage, remain high despite technical advances in MIO [3, 4]. This indicates a need for further improvements in gastric substitution during surgical resection of oesophageal cancer.

In a review of previous publications, different anastomotic methods were evaluated according to the route of gastric conduit, the method of anastomosis and the application of preconditioning. However, it was concluded that none of these techniques would result in differences in anastomotic leakage [5]. Although healthy blood supply and low tension of anastomosis were believed to be the main factors assuring the continuity of gastric conduit [6, 7], its association with gastric formation has been less studied.

In this study, we used a narrow gastric conduit in MIO and hypothesized that its usage would minimize leakage following surgery. We herein report our initial findings from a single centre based on our recent 2-year experience.

PATIENTS AND METHODS

The study was approved by the Ethics Committee of Zhongshan Hospital, Fudan University. Written informed consent was obtained from all the enrolled patients after careful explanation of the procedures. Between May 2011 and December 2012, 259 MIO cases were enrolled in this study. Patient demographics and tumour characteristics were collected after detailed consultation at admission. Tumour lesions were staged by means of endoscopy, tissue biopsy, thoracoabdominal computed tomography (CT) and endoscopic ultrasound. Based on clinical assessments, the inclusion criteria of this study were as follows:

(i) Patients with clinically staged T1-3N0M0 tumours;
(ii) Patients without a previous history of cancer;
(iii) Patients without a previous history of neck or chest surgery;
(iv) Patients with an American Society of Anesthesiologists score of I–II;
(v) The application of mechanical circular stapler for anastomosis.

The exclusion criteria of this study were as follows:

(i) Patients with pre-existing COPD/asthma/interstitial lung disease;
(ii) Patients with heart/liver/renal dysfunction;
(iii) The application of the retrosternal route for gastric pull-up;
(iv) Incidental injury to the gastroepiploic artery during the operation.

Perioperative management

Analgesia and anaesthesia. All the patients had a combination of epidural and general anaesthesia and were provided with patient-controlled analgesia postoperatively. Patients were intubated with single-lumen endotracheal tubes and received double-lung ventilation during the operation. Extubation was conventionally performed in the operating room at the end of the procedure.

Surgery. All surgeries were performed thoracoscopically and laparoscopically in three-stage Ivor Lewis McKeown style: (i) Thoracic surgery began with mobilization of the thoracic oesophagus: the azygous vein was doubly ligated and transected. The oesophageal arteries were divided using an ultrasonic blade, and the thoracic duct was carefully preserved. Circumferential mobilization of the oesophagus (including all surrounding lymph nodes, perioesophageal tissue and mediastinal pleura) was performed from the diaphragm to the thoracic inlet and the mediastinal lymph nodes were removed. Thoracic surgery was completed by placement of two intercostal drainage tubes and closure of the thoracic incisions; (ii) Abdominal surgery commenced with dissection of the gastrohepatic ligament at the lesser curvature of the stomach and exposure of right crus of the diaphragm. The left gastric artery was then ligated by hem-o-lock (Weck Surgical, Teleflex, Limerick, ME, USA) and dissected. The short gastric vessels were divided by ultrasonic shear coagulation (Ethicon Endo-Surgery, Inc., Cincinnati, OH, USA). In Group N, the gastric conduit was formed according to the technique described by Marmuse [8] (Fig. 1). The tubulization had a linear and oblique resection on the upper part and from right to left of the lesser curvature to the summit of the fundus. The cutting started at the bottom, 2 cm above the upper edge of the pylorus, and ran along the greater curvature at a distance set at 4 cm, with the resection terminating at the top on the summit of the fundus, and without contralateral blood supply from the right gastric artery. It was defined as a narrow gastric conduit (average width of the conduit was 3 cm). In Group W, the Akiyama technique was used [9] (Fig. 2). The tubulization provided with a linear and oblique resection on the upper part and from right to left of the lesser curvature to the summit of the fundus. The resection started under the first three collateral branches of the left gastric artery with preservation of blood supply from the 2 proximal branches of right gastric artery. It was defined as a wide gastric conduit (average width of the conduit was 5 cm). The cutting line of the gastric conduit was embedded by interrupted seromuscular suturing.

Analysis. Intraoperatively, the length of the gastric conduit was measured from the duodenal artery to the pyloric tip and recorded during the surgery. In the abdominal stage, the perfusion status (recorded as perfusion units, PU) of gastric conduit was analysed by means of a laser Doppler perfusion detector (PeriFlux 5010, Perimed, Sweden). The detector was applied to the surface of the gastric fundus, gastric body and gastric antrum separately for 2 min (Fig. 3). The PUs at the three positions were measured before and after conduit formation (recorded as PU_{pref} and PU_{postf} respectively). In the cervical stage, the detector was applied to the anastomotic site at the gastric fundus to measure the alteration of PU after anastomosis (PU_{ana}). The reduction in PU was recorded in the formation of PU_1/PU_2.

Gastric conduit

Formation. Patients were assigned to receive 5-cm-wide gastric conduits (from May 2011 to February 2012, Group W) and then 3-cm-wide gastric conduits (from March 2012 to December 2012, Group N) for gastro-oesophageal anastomosis. The surgical procedures were similar between Group N and Group W. The mobilized stomach was taken out through a mini incision (4 cm in length) and the gastric conduit was tubulized by using a linear cutting stapler (TLC 75, Ethicon Endo-Surgery, Inc., Cincinnati, OH, USA). In Group N, the gastric conduit was formed according to the technique described by Marmuse [8] (Fig. 1). The tubulization along the greater curve comprised wide resection of the right 2/3 of the stomach. The cutting started at the bottom, 2 cm above the upper edge of the pylorus, and ran along the greater curvature at a distance set at 4 cm, with the resection terminating at the top on the summit of the fundus, and without contralateral blood supply from the right gastric artery. It was defined as a narrow gastric conduit (average width of the conduit was 3 cm). In Group W, the Akiyama technique was used [9] (Fig. 2). The tubulization had a linear and oblique resection on the upper part and from right to left of the lesser curvature to the summit of the fundus. The resection started under the first three collateral branches of the left gastric artery with preservation of blood supply from the 2 proximal branches of right gastric artery. It was defined as a wide gastric conduit (average width of the conduit was 5 cm). The cutting line of the gastric conduit was embedded by interrupted seromuscular suturing.

Figure 1: Gastric conduit in Group N.
Anastomotic leakage. After surgery, cervical anastomotic failure was defined according to clinical or radiographical findings. Clinically, an anastomotic leakage was suspected whenever there was systemic (the vital signs and increased white blood cell counts) or local (inflammation at anastomotic site) clinical manifestations. Radiographically, all patients had a swallow test on the 7th postoperative day, and 40 ml iodine contrast media (Compound Meglumine Diatrizoate Injection) would be administered orally to confirm the intact and continuity of the gastric substitution. In cases of suspected leakage, anastomotic failure would be confirmed after opening the neck wound and observing swallowed water tissue from the wound. The samples from the cervical wound would be collected for microbiological culture, and antibiotics would be adjusted according to laboratory results.

Postoperative follow-up

At 1 month after the operation, all patients had physical examination on the cervical incisions in the clinic to find any anastomotic leakage. The follow-up continued every 4 months postoperatively. The leakage together with the survival rate at 1 year after the surgery was recorded and compared to show the difference between the two groups.

Data collection and statistical analysis

Clinical data, including patient demographics, tumour characteristics, operative features and the details of gastric conduits of the two groups, were collected from the clinical database of the Thoracic Division at the Zhongshan Hospital, Fudan University. Medical charts were reviewed to identify complications as per the Society of Thoracic Surgeons National Database.

Clinical information was recorded in Microsoft EXCEL for further processing. Statistical analyses were performed using the SPSS software (version 17.0) and using the Student’s t-test, and \( \chi^2 \) test. A two-sided \( P \)-value of less than 0.05 was considered to be statistically significant.

RESULTS

Clinical features

Between May 2011 and the end of 2012, 259 consecutive patients were deemed eligible for MIO at Zhongshan Hospital, Fudan University. There were 126 patients allocated to Group N (from March 2012 to December 2012) and 133 patients allocated to Group W (from May 2011 to February 2012). The groups were
comparable in patient demographics, including age, sex, body mass index, smoking history and tumour characteristics. None of the patients received neoadjuvant therapy before MIO.

All patients underwent thoracoscopic oesophagectomy without conversion to open thoracotomy. There were no significant differences between the two groups in the operation duration, blood loss or the need for blood transfusion (Table 1). The postoperative protocols of antibiotic regimen and nutritional support were the same between the two groups. Diet was resumed after assurance of an intact gastro-oesophageal anastomosis 7 days after the surgery.

**Gastric conduit**

The recorded length of the gastric conduit in Group N was significantly greater (39.1 ± 2.7 vs 35.6 ± 4.4 cm, \( P = 0.0021 \)) than in Group W. In terms of the perfusion, decreased PU was recorded in both groups after formation of the mobilized gastric conduit. The PU reductions at the gastric fundus, gastric body and gastric antrum were similar between Group N and Group W. After gastro-oesophageal anastomosis during cervical surgery, significantly lower perfusion at the proximal conduit was recorded in Group W than in Group N (28.1 vs 45.7%, \( P = 0.004 \)). The details of gastric conduit are shown in Table 2.

**Mortality and morbidity**

No intraoperative patient deaths occurred in either group. Complications were observed in a total of 89 patients in the study, and the rates were not statistically different between groups (32.5% in Group N vs 36.1% in Group W, \( P = 0.548 \)). A total of 34 cases of anastomotic leakage (13.13%) was observed in this cohort. The incidence of anastomotic leakage was lower in Group N than in Group W (8.7 vs 17.3%, \( P = 0.041 \)). In the cases of leakage, patients fasted and were then fed through a jejunal tube. The cervical incision was explored, and daily debridement was performed until the leakage was cured. In this study, all of the leakage cases recovered after conservative therapy. There was no significant difference in 30-day mortality between the two groups (Table 3). Anastomotic leakage was not observed during the patients’ follow-up in the clinic, and the survival rates were close in the first year follow-up between the two groups (79.4% in Group N vs 81.2% in Group W, \( P = 0.710 \)).

**DISCUSSION**

Gastro-oesophageal anastomosis remains a challenge for thoracic surgeons in the surgical resection of oesophageal cancer. In this

### Table 1: Clinical features

<table>
<thead>
<tr>
<th></th>
<th>Group N (n = 126)</th>
<th>Group W (n = 133)</th>
<th>( P )-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patient</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>60.9 ± 9.0</td>
<td>62.6 ± 8.7</td>
<td>0.123*</td>
</tr>
<tr>
<td>Sex (male)</td>
<td>102 (81.0%)</td>
<td>105 (78.9%)</td>
<td>0.687*</td>
</tr>
<tr>
<td>Body mass index</td>
<td>24.2 ± 3.5</td>
<td>23.7 ± 4.0</td>
<td>0.286*</td>
</tr>
<tr>
<td>Comorbidity</td>
<td>43 (34.1%)</td>
<td>39 (29.3%)</td>
<td>0.406*</td>
</tr>
<tr>
<td>Smoking history</td>
<td>88 (69.8%)</td>
<td>95 (71.4%)</td>
<td>0.779*</td>
</tr>
<tr>
<td><strong>Tumour</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location (U; M; L)</td>
<td>12; 91; 13</td>
<td>15; 101; 17</td>
<td>0.228*</td>
</tr>
<tr>
<td>Histology (SC; AD)</td>
<td>120 (95.2%)</td>
<td>130 (97.7%)</td>
<td>0.446*</td>
</tr>
<tr>
<td>Pathological stage</td>
<td></td>
<td></td>
<td>0.438*</td>
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<tr>
<td></td>
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<tr>
<td><strong>Surgery</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Abdominal duration (min)</td>
<td>72.4 ± 22.5</td>
<td>68.9 ± 17.9</td>
<td>0.166*</td>
</tr>
<tr>
<td>Operation duration (min)</td>
<td>162.5 ± 43.1</td>
<td>167.2 ± 33.5</td>
<td>0.327*</td>
</tr>
<tr>
<td>Blood loss (ml)</td>
<td>109.6 ± 30.9</td>
<td>105.5 ± 28.4</td>
<td>0.267*</td>
</tr>
<tr>
<td>Blood transfusion</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

*a*By Student’s t-test.  
*b*By \( \chi^2 \) test.  
U: upper; M: middle; L: lower (thoracic oesophagus); SC: squamous cancer; AD: adenocarcinoma.

### Table 2: Analysis of gastric conduit

<table>
<thead>
<tr>
<th></th>
<th>Group N (n = 126)</th>
<th>Group W (n = 133)</th>
<th>( P )-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (cm)</td>
<td>39.1 ± 2.7</td>
<td>35.6 ± 4.4</td>
<td>0.021*</td>
</tr>
<tr>
<td>Perfusion</td>
<td>(PU_postF/PU_preF)</td>
<td>(PU_postF/PU_preF)</td>
<td></td>
</tr>
<tr>
<td>Gastric conduit</td>
<td>44.30%</td>
<td>51.70%</td>
<td>0.082*</td>
</tr>
<tr>
<td>Gastric fundus</td>
<td>78.40%</td>
<td>70.30%</td>
<td>0.509*</td>
</tr>
<tr>
<td>Gastric body</td>
<td>86.10%</td>
<td>90.50%</td>
<td>0.373*</td>
</tr>
<tr>
<td>Gastric antrum</td>
<td>45.70%</td>
<td>28.10%</td>
<td>0.004*</td>
</tr>
</tbody>
</table>

*a*By Student’s t-test.
study, we used a narrow gastric conduit in MIO to determine whether its usage would minimize leakage following surgery. We found that narrow gastric tubes were longer and less interfered in perfusion compared with wider ones, which contributed to a lower incidence of anastomotic leakage following MIO.

Historically, narrow gastric conduit was preferred in transhiatal oesophagectomy because it could be pulled up for the cervical anastomosis [8]. In transthoracic surgery, significantly larger length was recorded when the gastric tube was narrowed to 2.5–3 cm. Given that the greater curvature was longer than the lesser curvature, the cutting line along the gastroepiploic artery was longer if it was closer to the greater curvature. Similar technique was described by Schärl, in which esophagus was elongated for 6–8 cm in the treatment of atresia [10]. Prolonged gastric conduit, applied as the oesophageal substitution, resulted in lower tension to the proximal oesophagus following anastomosis, which helped in preserving the intact oesophageal reconstruction.

Previous studies, either of gastric formation or of anastomotic methods, were based on improvements in blood supply in the reconstruction of gastric conduits [11, 12]. Therefore, the laser Doppler perfusion monitor was introduced to analyse changes in perfusion before and after gastric tubulization. Given that the gastric conduit formed during MIO was primarily supported by the right gastroepiploic artery, narrower conduits might have better blood supply than wider ones. However, the changes in perfusion were comparable between the two groups at all three points when the gastric conduit was formed. This could be explained by the contribution of the contralateral blood supply from the preserved branches of right gastric artery [13], which was preserved in Group W. Similar findings were reported by Sugimachi in an animal model, in which alteration of blood flow was similar between different widths of gastric conduits from 3 to 5 cm [14].

During the cervical procedure of this current study, further perfusion reduction was observed in both groups following gastro-oesophageal anastomosis. Technically, the gastric conduit was Anastomosed with cervical oesophagus with tension and was kept in the thoracic cavity in a false pressure environment. Therefore, the perfusion status of the proximal conduit following the anastomosis was closer to the ultimate changes in blood supply during oesophagectomy. By contrast significant perfusion reduction after anastomosis would contribute to high incidence of cervical leakage following MIO, which helped in explaining the difference in leakage between the two groups.

In this study, higher PUs were recorded in Group N following gastro-oesophageal anastomosis. This was partly because of the larger length of gastric conduit in Group N, which might have resulted in lower tension after anastomosis [15]. In addition, the preserved branches from right gastric artery during tubulization would be anatomically distant from the cervical anastomosis, making the narrowed gastric conduit superior, because there would be less tissue requiring blood perfusion than in those of wider conduits. This could explain the lower PU reduction recorded in Group N during the cervical procedure.

Besides the evidence from gastric analysis, several factors have been reported to be associated with anastomotic leakage following oesophagectomy [16], and these factors could contribute to the potential bias of the study. To minimize bias, the inclusion criteria were restricted to: (i) the surgeries were performed by the same experienced surgeon, who had performed over 300 MIOs before the beginning of the study; (ii) only circular stapler anastomotic techniques were applied so that the leakage incidence would not interfere with other anastomotic methods; and (iii) only patients were included in whom the oesophageal bed was used as the route for the conduit pull-up, because the retrosternal route has been reported to be longer than the posterior route [17]. However, the sequential application of two gastric conduits would have built-in bias of learning curve effects in this retrospective study. However, leakage was decreased by half by using narrowed gastric conduits, and the incidence was considered higher than attributable to chance alone, because the experience with MIO would minimize the latter effect as described in a previous publication [18].

Delayed emptying following oesophagectomy is a potential major concern after the application of a narrowed gastric conduit. In this study, the overall incidence of delayed gastric emptying was low and nearly identical between the two groups. Even when pyloroplasty was not performed in this study, the motor activity of oesophageal substitution was kept without compromising gastric emptying. By contrast, as described by Lee et al. [19], a narrow gastric tube improves gastric emptying in a flow-visualization model. Similar findings were reported by Zhang et al. [20] in a randomized and controlled trial, in which the application of a narrow gastric tube was found to be associated with improved postoperative quality-of-life score.

In the current study, conduit length and blood supply were found to be superior in the narrowed gastric conduit group, and the incidence of leakage following the operation was significantly lower. This suggests that the optimal width of gastric conduits might be decreased for patients undergoing oesophagectomy. However, because the wide and narrow gastric conduits were before the narrow gastric conduits in this retrospective study, there was no supportive evidence that a wide gastric conduit should be transected to a narrow one intraoperatively according to the perfusion status, whereas further study of a cut-off value of PU would be helpful in determining the formation of gastric conduit.

The limitations of our study were its retrospective design and lack of exploration of the long-term effects of narrowed gastric tubes, especially on quality of life. Therefore, a randomized controlled trial (NCT 01696662) has been commissioned for expansion on our initial findings of anastomotic leakage following minimally invasive oesophagectomy.
Funding

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Conflict of interest: none declared.

REFERENCES


APPENDIX. CONFERENCE DISCUSSION

Dr T. Rice (Cleveland, OH, USA): This was a retrospective review. Were the 2 groups done simultaneously or did you have an early and a late group?

Dr Tan: The narrow conduit is the late group.

Dr Rice: Because you could propensity match them but time would be a problem because you learned with your first group and you applied that to your second group. So it’s unfortunate you didn’t try to do them at different times. You still might give a propensity score to get the bias out of the study, but it is somewhat limited. Can I give you a little comment on your style?

Dr Tan: Okay.

Dr Rice: You spent so much time telling us about the literature, but I want to know what you learned. So just tell me your hypothesis and how you are going to prove it and show me your data. That’s all I need to know.

Dr Tan: When we did an intrathoracic anastomosis, we didn’t have such a high rate of leakage, so we thought about why we had relatively high leakage with the anastomosis in the neck. We used the same circular stapler method. So the only thing that could have influenced the leakage is the blood supply of the conduit.

Dr Rice: But I want to know what you think, what your hypothesis is and how you are going to test it. I don’t care what has been written. I know the literature. So it is different presenting a talk versus giving me a paper. So you have got to teach me really quickly, okay?

Dr Tan: Okay.

Dr T. Lenut (Leuven, Belgium): I think it is good that we have presentations on what is still considered as the Achilles heel of oesophageal surgery. This is more like a comment and then a question. It is important, first of all, not to traumatize the top of the fundus, and also to dissect as close as possible to the hilum of the spleen, taking all the fat. So my question is, did you do this? Secondly, I do agree that the narrow tube makes the conduit longer than a wider tube, allowing us to resect the possibly traumatized top part. Are you doing a resection of the top part of the fundus when performing the anastomosis?

Dr Tan: In every case we try to keep the right gastroepiploic artery and some branches of the left epiploic artery, but sometimes when patients have dense adhesions to their spleen, we cannot achieve this. We use a much longer tube to facilitate the anastomosis, and we try to do the anastomosis close to the right epiploic artery to keep a good blood supply in that area, and then we transect the proximal fundus of the gastric conduit.